Problem 41

Refer to Figure 5. In Figure 5(a), the ratio of the linear decrease on loss between connection 1 and connection 2 is the same - as ratio of the linear increases: unity. In this case, the throughputs never move off of the AB line segment. In Figure 5(b), the ratio of the linear decrease on loss between connection 1 and connection 2 is 2:1. That is, whenever there is a loss, connection 1 decreases its window by twice the amount of connection 2. We see that eventually, after enough losses, and subsequent increases, that connection 1's throughput will go to 0, and the full link bandwidth will be allocated to connection 2.

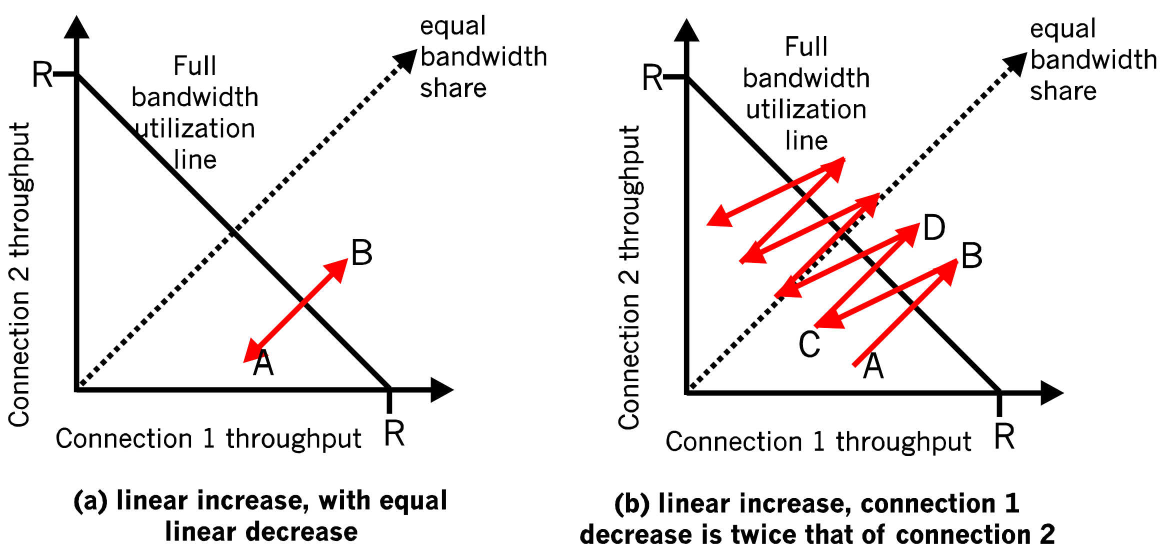


Figure 5: Lack of TCP convergence with linear increase, linear decrease

Problem 45

a) The loss rate, L, is the ratio of the number of packets lost over the number of packets sent. In a cycle, 1 packet is lost. The number of packets sent in a cycle is

$$\frac{W}{2} + \left(\frac{W}{2}+1\right) + \cdots + W = \sum_{n=0}^{W/2}\left(\frac{W}{2}+n\right)$$

$$= \left(\frac{W}{2}+1\right)\frac{W}{2} + \sum_{n=0}^{W/2} n$$

$$= \left(\frac{W}{2}+1\right)\frac{W}{2} + \frac{W/2(W/2+1)}{2}$$

$$= \frac{W^2}{4} + \frac{W}{2} + \frac{W^2}{8} + \frac{W}{4}$$

$$= \frac{3}{8}W^2 + \frac{3}{4}W$$

Thus the loss rate is

$$L = \frac{1}{\frac{3}{8}W^2 + \frac{3}{4}W}$$

b) For W large, $\frac{3}{8}W^2 >> \frac{3}{4}W$. Thus $L \approx 8/3W^2$ or $W \approx \sqrt{\frac{8}{3L}}$. From the text, we therefore have

$$\text{average throughput } = \frac{3}{4}\sqrt{\frac{8}{3L}} \cdot \frac{MSS}{RTT}$$

$$= \frac{1.22 \cdot MSS}{RTT \cdot \sqrt{L}}$$

Problem 1

a) With a connection-oriented network, every router failure will involve the routing of that connection. At a minimum, this will require the router that is "upstream" from the failed router to establish a new downstream part of the path to the destination node, with all of the requisite signaling involved in setting up a path. Moreover, all of the routers on the initial path that are downstream from the failed node must take down the failed connection, with all of the requisite signaling involved to do this.

   With a connectionless datagram network, no signaling is required to either set up a new downstream path or take down the old downstream path. We have seen, however, that routing tables will need to be updated (e.g., either via a distance vector algorithm or a link state algorithm) to take the failed router into account. We have seen that with distance vector algorithms, this routing table change can sometimes be localized to the area near the failed router. Thus, a datagram network would be preferable. Interestingly, the design criteria that the initial ARPAnet be able to function under stressful conditions was one of the reasons that datagram architecture was chosen for this Internet ancestor.

b) In order for a router to maintain an available fixed amount of capacity on the path between the source and destination node for that source-destination pair, it would need to know the characteristics of the traffic from all sessions passing through that link. That is, the router must have per-session state in the router. This is possible in a connection-oriented network, but not with a connectionless network. Thus, a connection-oriented VC network would be preferable.

c) In this scenario, datagram architecture has more control traffic overhead. This is due to the various packet headers needed to route the datagrams through the network. But in VC architecture, once all circuits are set up, they will never change. Thus, the signaling overhead is negligible over the long run.

Problem 4

a) Data destined to host H3 is forwarded through interface 3

Destination Address	Link Interface
H3	3

b) No, because forwarding rule is only based on destination address.

c) One possible configuration is:

Incoming interface	Incoming VC#	Outgoing Interface	Outgoing VC#
1	12	3	22
2	63	4	18

Note, that the two flows could actually have the same VC numbers.

d) One possible configuration is:

Router B.

Incoming interface	Incoming VC#	Outgoing Interface	Outgoing VC#
1	22	2	24

Router C.

Incoming interface	Incoming VC#	Outgoing Interface	Outgoing VC#
1	18	2	50

Router D.

Incoming interface	Incoming VC#	Outgoing Interface	Outgoing VC#
1	24	3	70
2	50	**3**	**76**

Problem 7

a) No, you can only transmit one packet at a time over a shared bus.

b) Yes, as discussed in the text, as long as the two packets use different input busses and different output busses, they can be forwarded in parallel.

c) No, in this case the two packets would have to be sent over the same output bus at the same time, which is not possible.

6. Problem 6 is given as follows.

Consider the evolution of a TCP connection with the following characteristics. Assume that all the following algorithms are implemented in TCP congestion control: slow start, congestion avoidance, fast retransmit and fast recovery, and retransmission upon timeout. If ssthresh equals to cwnd, use the slow start algorithm in your calculation.

• The receiver acknowledges every segment, and the sender always has data available for transmission. All TCP segments have the same size (say, 1 unit).

• The network latency in sending a segment (header and payload) from the sender to the receiver is 30ms and the network latency in sending an acknowledgment (header only) from the receiver to the sender is 20ms. Ignore packet processing delays at the sender and the receiver.

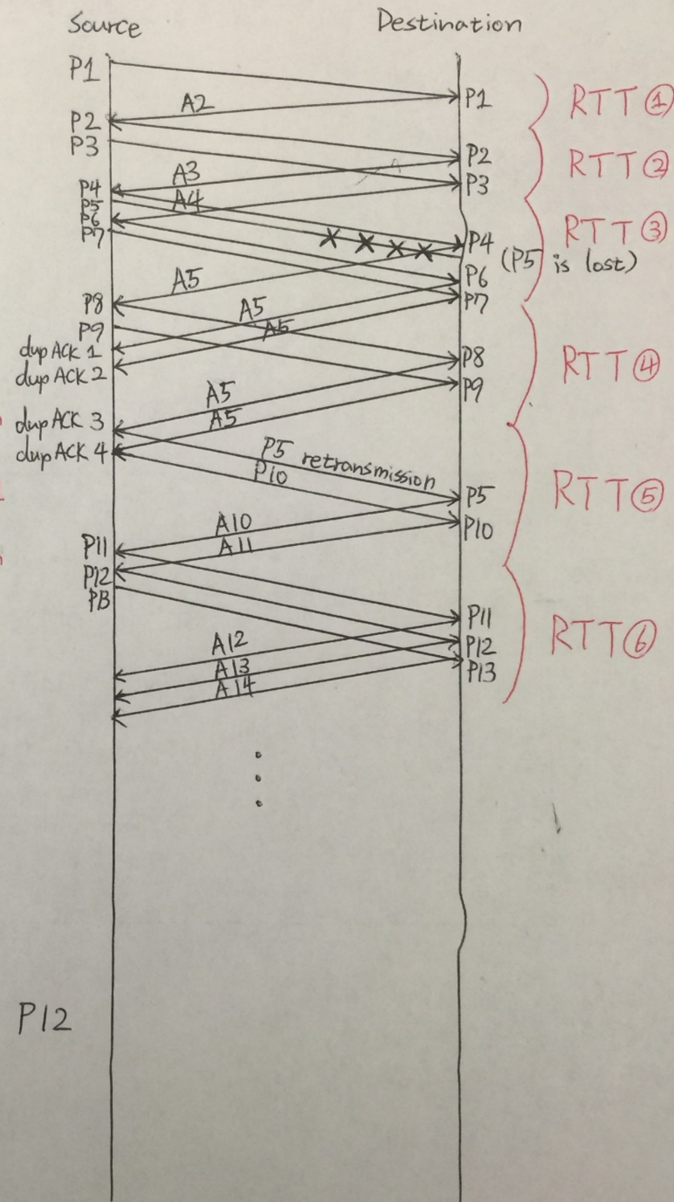
• Initially ssthresh at the sender is set to 4. Assume cwnd and ssthresh are measured in segments. Retransmission timeout (RTO) is initially set to 500ms at the sender and updated to 150 ms during the connection lifetime.

• The connection starts to transmit data at time t = 0, and the initial sequence number starts from 1. Segment with sequence number 5 is lost once. No other segments are lost.

How long does it take, in milliseconds, for the sender to receive the ack for the segment with the sequence number 12? show your diagram.

[P6]

	SSThresh	CWND
	4	1
Slow Start	4	2
slow start	4	3
Slow Start	4	4
Slow Start	4	5
Fast Retransmit	2 = $\cancel{\text{min}}$ max $(\lfloor \frac{5}{2} \rfloor, 2)$	5 = SSThresh +3
Fast Recovery	2	6 = CWND +1
	2	2 = SSThresh
Slow Start	2	3



$$RTT = 30\ ms + 20\ ms$$
$$= 50\ ms$$

Time to receive the ACK for the P12

$= 6\,RTT$

$= 300\ ms$